Interactive Global Illumination in Dynamic Scenes

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Interactive Global Illumination

- **For modeling and lighting design**
- **Requirements :**
  - Interactive movement of objects and lights
  - Camera motion with view-dependent lighting
  - Quick feedback about changes in illumination
  - Little or no pre-computation

Previous Work

- **Radiosity-based**
  - Interactive HR - Drettakis and Sillion ’97
- **Hardware based**
- **Caching schemes**
  - RenderCache – Walter et al ’99
  - Tapestry – Simmons and Sequin ’00
  - Corrective Texturing – Stamminger et al ’00

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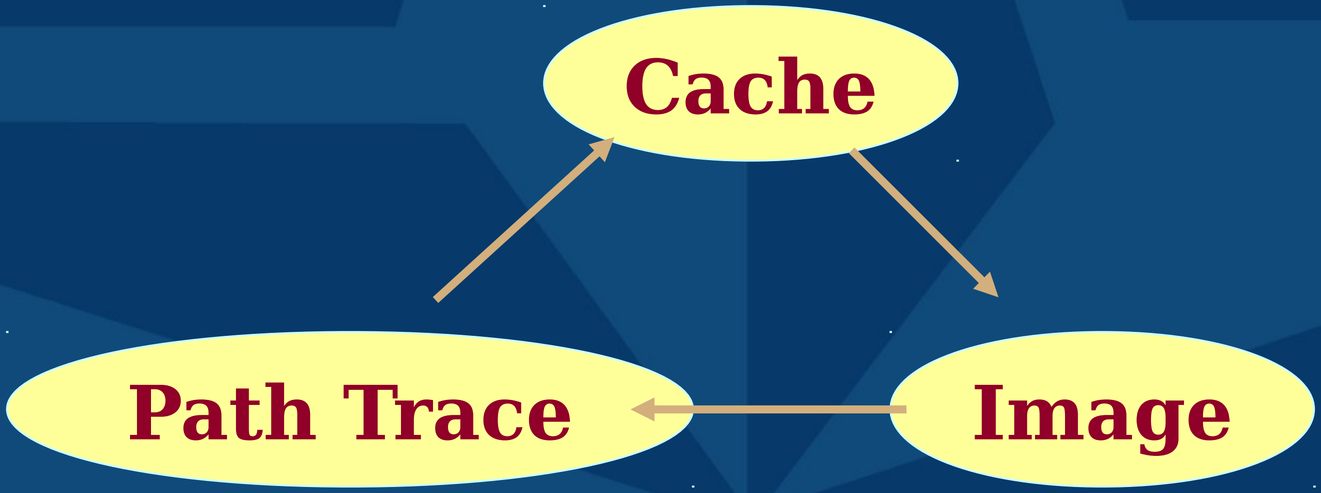
Why do we need caching?

- **Global illumination using path tracing is very slow**
  - Can compute about 10 - 100 pixels/second on a Pentium 4
  - But need 10 million pixels/second for 640 X 480 images at 30 frames/second
- **Try to produce an image without path tracing each pixel**

Overview of Caching Schemes



- Image update independent of ray-tracing speed
- Synchronous updates (2 - 10+ cycles/sec)

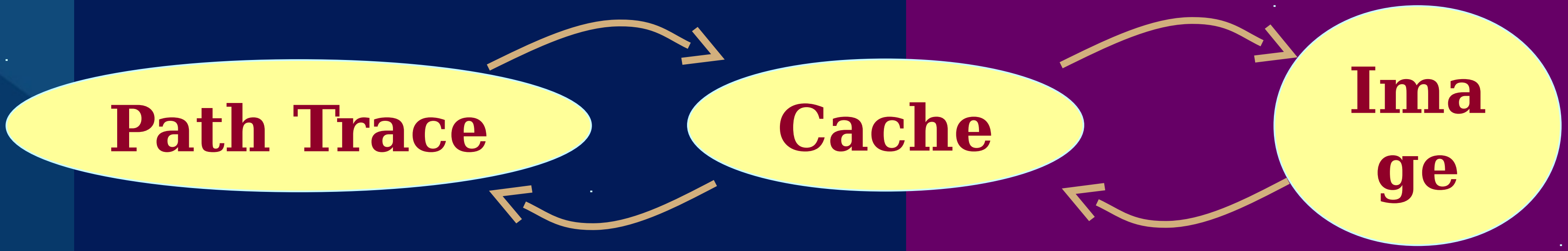
Our System

Cache Update

~ 2 cycles/second

Image Update

30 frames/second



Path Trace

Cache

Ima
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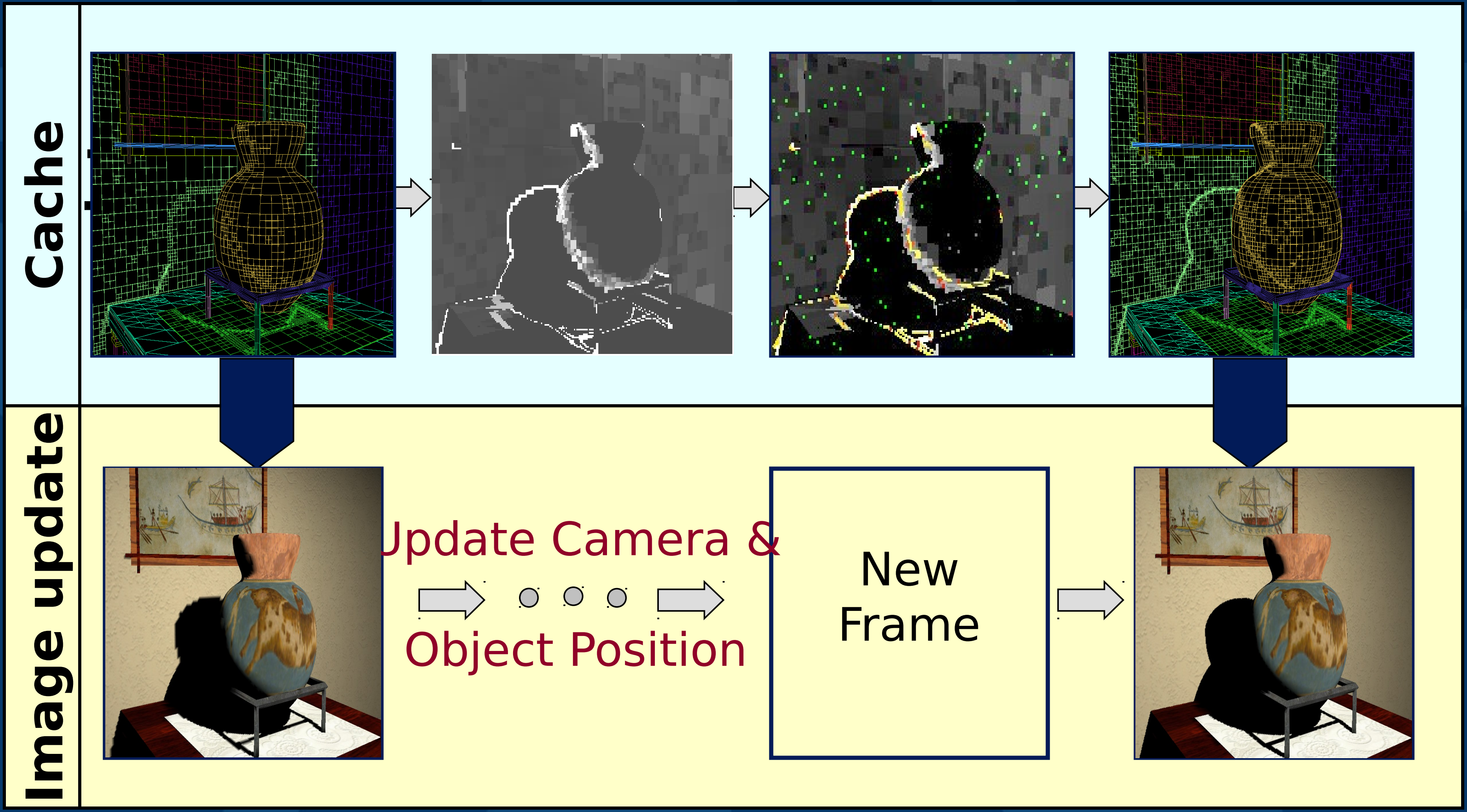
System Overview



Cache

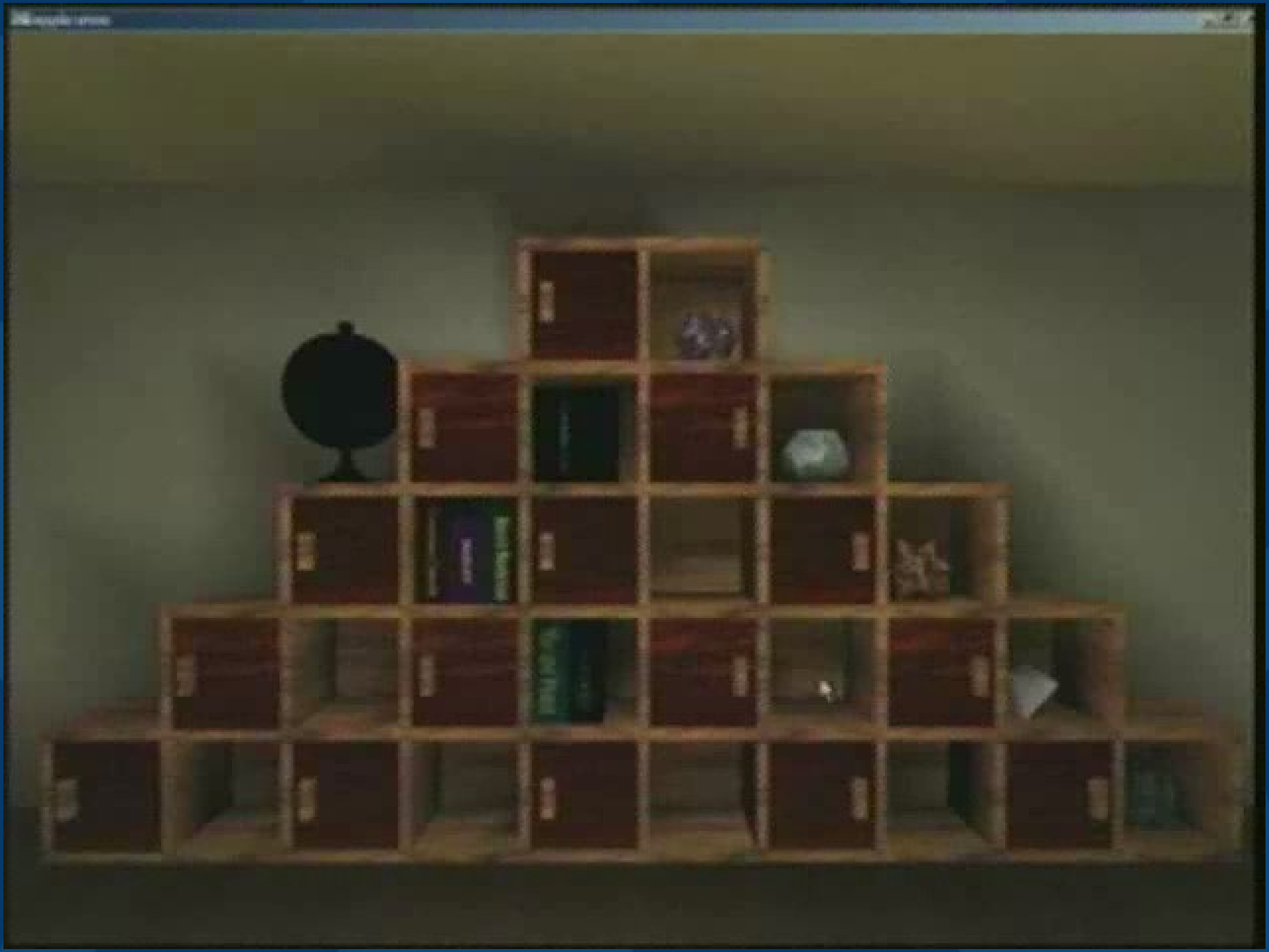
Image update

Update Camera &

Object Position

New Frame

System Overview



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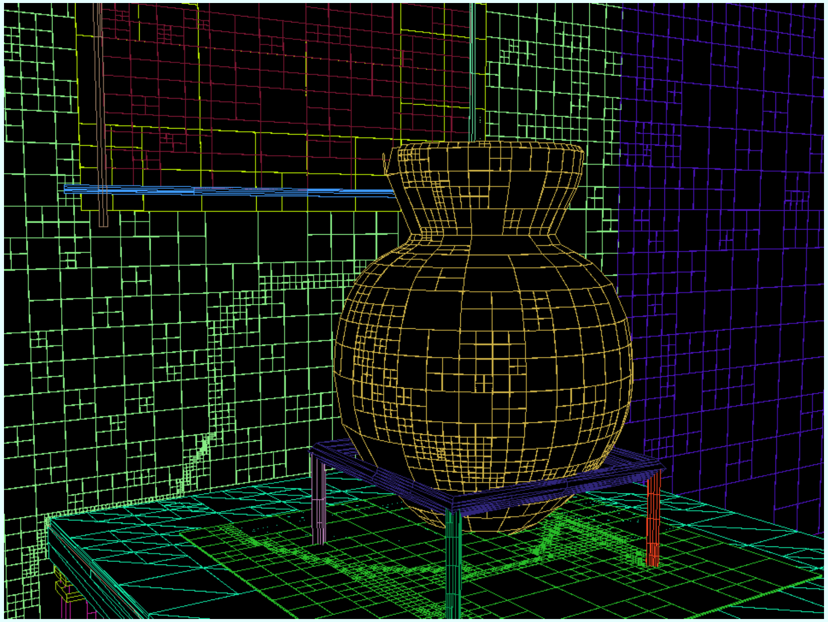
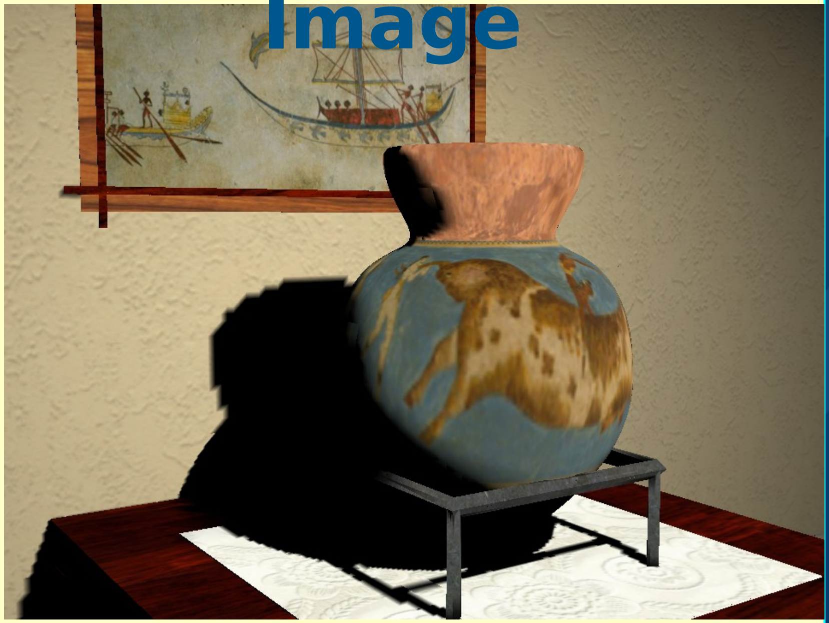
The Shading Cache

Shading Cache



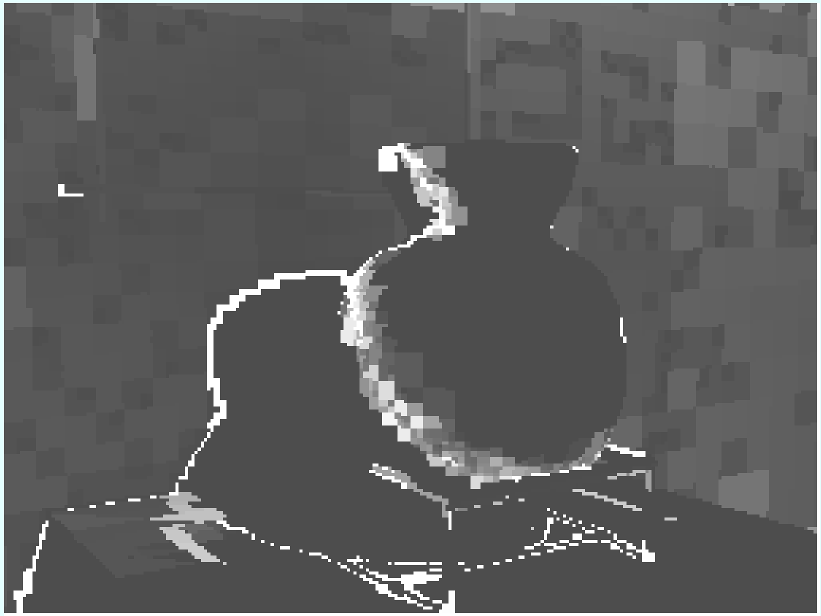
Reconstructed Image



- Hierarchical subdivision mesh in object space
- Shading Cache + Geometry + Texture = Image

Shading Cache Update

Priority Map



- Estimated interpolation error for gradients
- Aging to detect dynamic view-dependent changes

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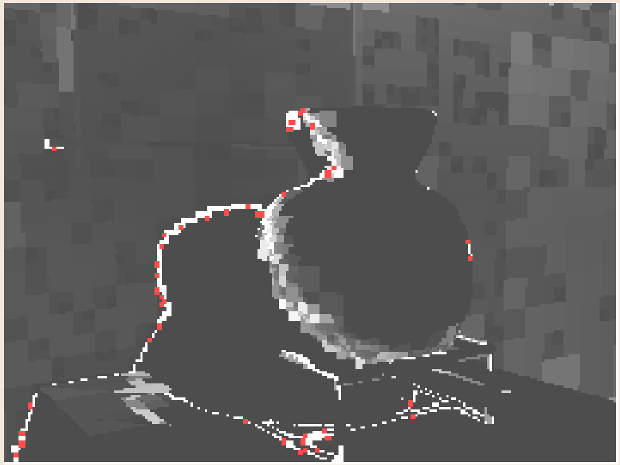
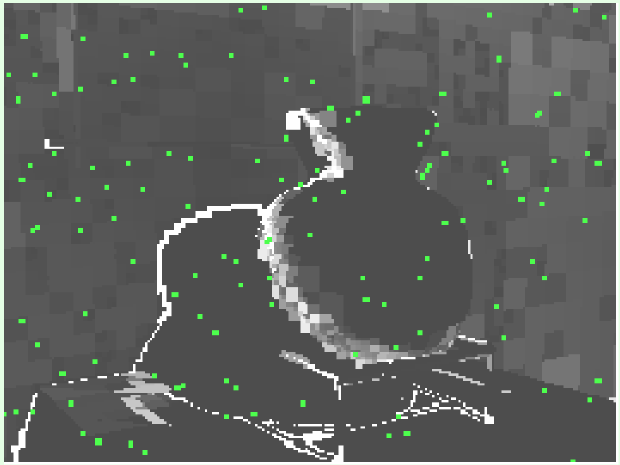
Shading Cache Update

Sample Selection



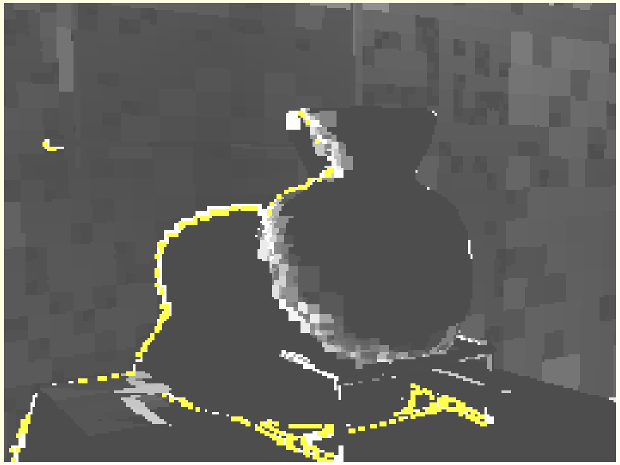
Hit-and-test Samples

To reduce error



Random Samples

To prevent bias

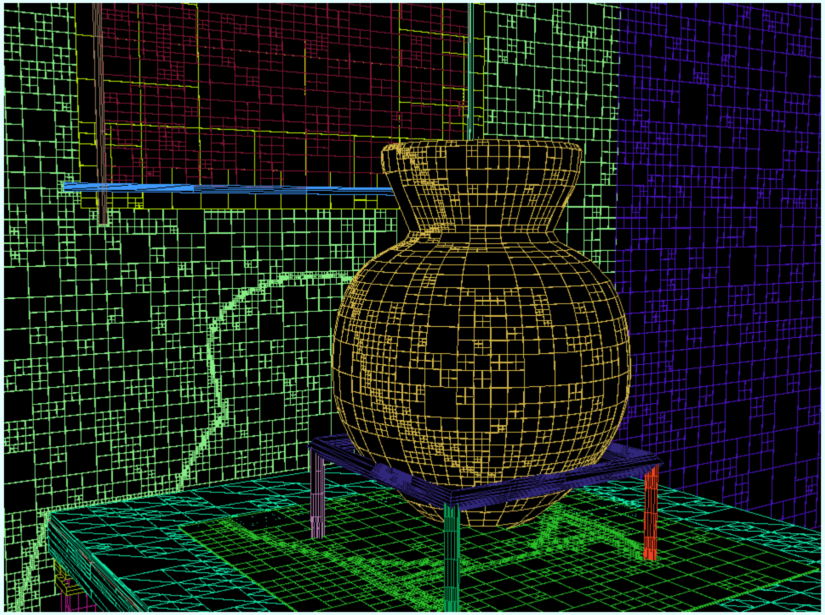


Flood filled samples

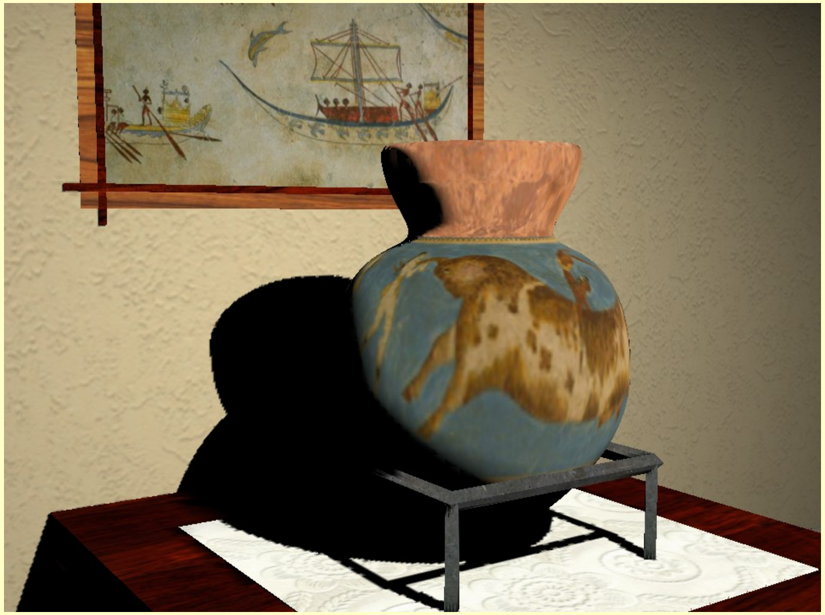
To reconstruct edges

Shading Cache Update

Updated Cache



New Image



Progressive refinement of shading up to one patch per pixel

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Cache Management

- **Delete old patches**
- **Cache only as much as you can update**
  - Detect image regions with changing illumination
  - Reduce target-resolution for cache in those parts
  - Increase target-resolution later

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Implementation details

- **Dual Pentium 4 for cache update and image display**
- **Parallel Sample Renderer**
  - Bi-directional path tracing (400-1200 samples)
  - 16 Pentium 4 CPUs used for the results
  - About 10 - 100 pixels/second on one 1.7 GHz P4
- **Image update displays 10 million pixels per second!**

Results

4,000 primitives, 1 area light source

Soft shadows, diffuse and non-diffuse reflections

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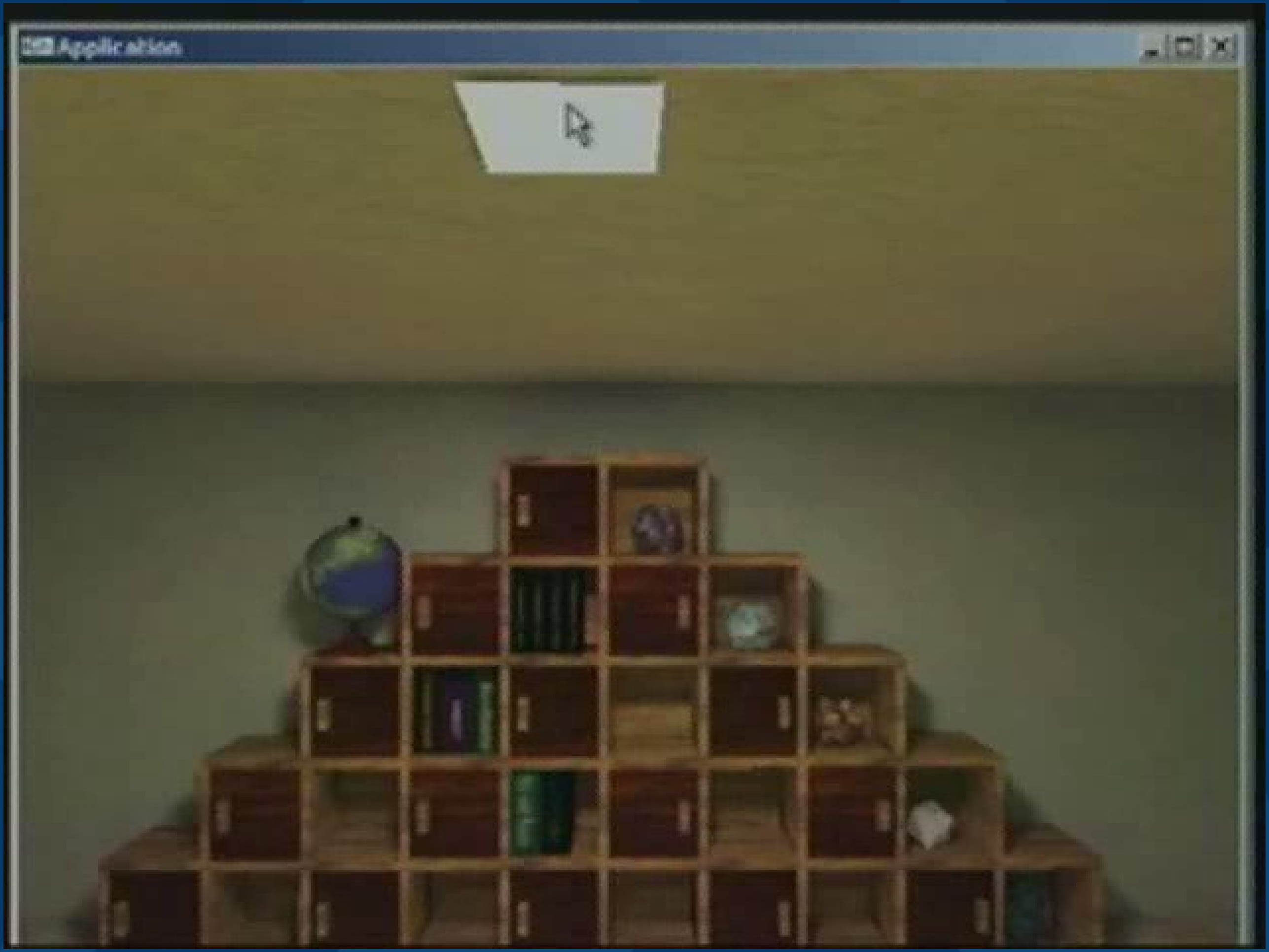
Results - Moving Lights



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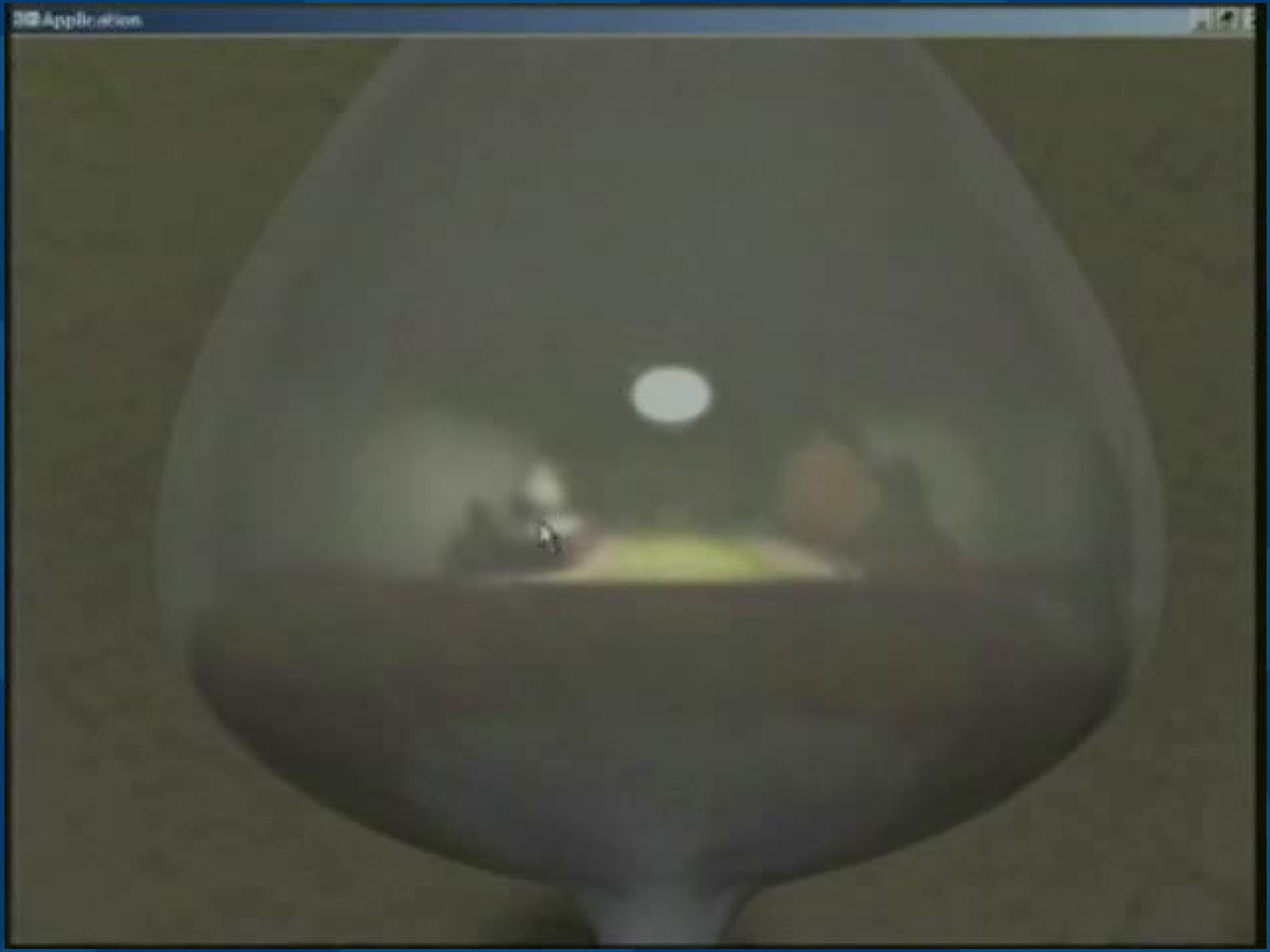
Results – Glossy reflections



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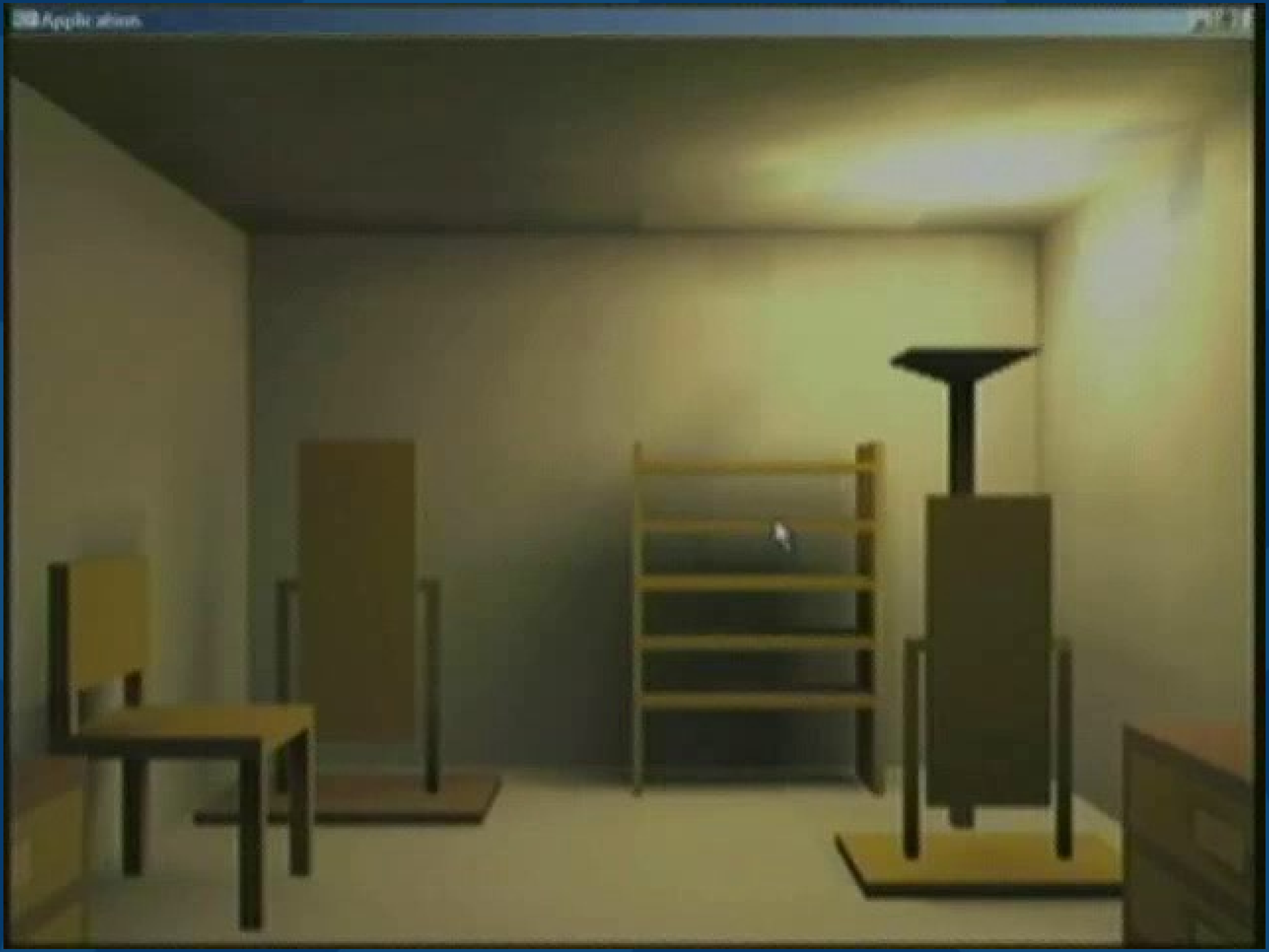
Results

300 primitives, 1 area light source

Strong diffuse inter-reflections

Results – Moving Objects



Results

- **Good shading quality in few seconds**
- **High frame rate display (30+ fps)**
- **Very low overhead for caching (~10%)**
- **Scalability (tested up to 32 CPUs)**

Summary

- **Spatial separation**
  - Separate shading from visibility
  - Accurate display of geometry and textures
- **Temporal separation**
  - Asynchronous update of shading
  - High frame rates
  - Smooth camera and object motion

Summary

- **Object-space cache**
  - More suitable for dynamic scenes
  - Exploit spatial and temporal coherence
  - Object-space data available for sampling
- **View-driven update**
  - Allows pixel-level accuracy

Future work

- **Handling more complex scenes**
  - LOD and occlusion culling for high frame rate
  - Cluster shading values – Texture coordinate assignment problem
- **Better reconstruction**
  - Blending to reduce aliasing and popping
  - Faster updates for view-dependent shading
- **Higher level error metrics for sampling**

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